Carbon Cycling in the Southern Great Plains: The ARM/LBNL Carbon Project

Margaret S. Torn, M.L. Fischer, William J. Riley, I. Pesenson, and J. Berry
Contact: Margaret S. Torn, 510/495-2223, mstorn@lbl.gov

RESEARCH OBJECTIVES

One of the challenges in carbon cycle research is the vast range of scales, from plants to continents, that must be bridged with measurements and models. The Atmospheric and Radiation Measurement (ARM)/LBNL Carbon Project is making a coordinated suite of carbon concentration, isotope, and flux measurements to support a range of scaling and integration exercises, including those proposed for the North American Carbon Program:

- Quantify the regional atmospheric CO_2 budget.
- Predict carbon fluxes, and the effect of land use and climate on them.
- Link local processes to regional and global models.

APPROACH

We are working at the DOE ARM Southern Great Plains testbed, a GCM-grid sized area centered in Northern Oklahoma. The carbon cycle data streams that our group produces are centered at the 60 m tower of the ARM Central Facility and include: precise CO_2 concentration profiles; carbon eddy covariance fluxes; National Oceanic and Atmospheric Administration–Climate Monitoring Diagnostics Laboratory (NOAA-CMDL) flasks in the mixed layer and free troposphere; and diurnal profiles of ^{13}C and ^{18}O in CO_2. In the next year, we are adding continuous CO measurements and flask sampling for $^{14}CO_2$ to assist with source attribution.

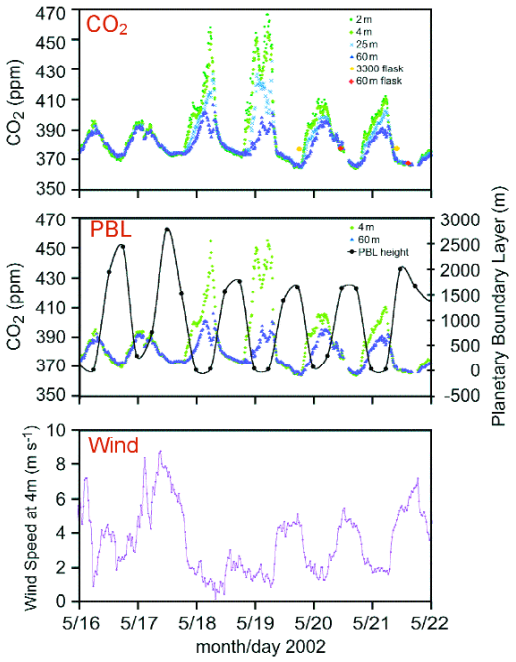

Figure 1. Diurnal cycle of CO_2, PBL height, and wind speed, May 16–22, 2002. Data were collected at the ARM Central Facility: CO_2 concentrations are from the continuous precise system at 60 m tower; red and yellow symbols are NOAA-CMDL flask data. PBL height was estimated from radiosonde profiles. Windspeed was measured at 4 m at the base of tower.

ACCOMPLISHMENTS

The continuous precise CO_2 measurements and the NOAA flask sampling tie the ARM testbed to the global atmospheric network. We observe that CO_2 concentrations are higher than global average for the latitude, reflecting continental sources. The diurnal cycle also shows the influence of continental atmospheric and terrestrial processes. At night (as seen in Figure 1), soil respiration and stable conditions lead to large buildups in CO_2, especially near the surface. During the daytime, the atmosphere is well mixed and photosynthesis reduces atmospheric CO_2 concentrations. The highest concentrations of CO_2 are on nights of low wind speed and low mixing height. Our flux studies indicate that land use is the most important driver of spatial heterogeneity in fluxes in the study area. Using these results, regional-scale estimates of carbon fluxes based on "top-down" (atmospheric concentrations) and "bottom up" (distributed modeling and eddy flux measurements) approaches are in progress.

SIGNIFICANCE OF FINDINGS

Observations of Atmospheric CO_2 concentrations can improve estimates of surface fluxes, source types, and total atmospheric CO_2 stocks. However, the diurnal cycle of CO_2 concentration at continental sites reflects not only net ecosystem exchange, but also atmospheric mixing (planetary boundary layer) advection from surface winds, and anthropogenic carbon sources. Thus, interpreting atmospheric concentrations also requires understanding atmospheric processes and anthropogenic activity.

The isotopic and molecular composition of atmospheric samples creates fingerprints of fossil, biomass burning, and biogenic sources of carbon cycle gases. Our ongoing research efforts are focused on joining models of isotopic and atmospheric processes with land use patterns, and testing output against data covering multiple spatial and temporal scales.

RELATED PUBLICATION

ARM Carbon Web Site: http://esd.lbl.gov/ARMCarbon/

ACKNOWLEDGMENTS

This work was supported by the U.S. Department of Energy Atmospheric Radiation Measurement Program, Office of Science, of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.